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# TIMS Data from HAPEX-Sahel

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## 1. INTRODUCTION

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TIMS data were acquired in August and September 1992 as part of the Hydrological and Atmospheric Pilot Experiment in the Sahel (HAPEX-Sahel; Goutorbe et al., 1997). The latter is an international land-surface-atmosphere observation program that was undertaken in western Niger, in the West African Sahel region. The overall aims were to improve our understanding of the role of the Sahel on the general circulation, in particular the effects of the large interannual fluctuations of land surface conditions in this region. The field program obtained measurements of atmospheric, surface and certain sub-surface processes in a 1deg x1deg area that incorporates many of the major land surface types found throughout the Sahel. In order to obtain data for this large area, an extensive remote sensing program was undertaken including field, aircraft, and satellite measurements. An intensive operations period was undertaken for 8 weeks from mid to late growing season of 1992. The aim of HAPEX-Sahel was to make simultaneous measurements of relevant variables at the micro and meso scales. The heterogeneity of surface types and seasonal variation in the region are much greater than in the areas studied in any previous measurement campaigns of this type. To address this aspect of the problem the remote sensing program was used to extend the field measurements to the entire region, i.e to the meso-scale. One component was performed by a suite of sensors on NASA's C-130 aircraft. These included a microwave radiometer for soil moisture observations (Chanzy et al., 1997), a visible and near IR scanner (NS001) for vegetation and albedo data and a thermal infrared scanner (TIMS) for surface temperature and emissivity.

TIMS was flown at several altitudes ranging from 300 m to 5000 m, yielding pixel sizes from 0.75 to 12.5 m. The data presented in this study were acquired on September 2 and September 4, 1992 at an altitude of 600 m yielding a spatial resolution of 1.5m. At this altitude the ground speed exceeded the scan speed and the data are under scanned with each scanline being approximately 3m apart. The radiances at the aircraft were corrected for the effects of the atmosphere using the MODTRAN radiative transfer model (Berk et al., 1989) and radiosoundings of the atmosphere made about 20 km east of the central sites and within about an hour of the flight (Bessemoulin and Trauille, 1997). The problem then remains of separating the surface temperature and emissivity effects in the observed radiances. This was done using the Temperature Emissivity Separation (TES) algorithm being developed for use with ASTER data to be coming from the EOS-AM platform (Gillespie, et al., 1996; Matsunaga, 1994; Fujisada, 1994).

## 2. RESULTS

(a)

year or field

The radiances for 3 selected targets in the scene for the east central site were obtained from the images. The sites were: a fully vegetated section of the tiger bush, a bare soil and highly vegetated section of a millet field. The brightness temperatures ($T_B$) before and after atmospheric correction are presented in Fig. 1. These results are from line 3 on September 4, 1992. They show about a 10 K range of $T_B$ for the bare soil field after correction and less 0.5 K range for the tiger bush. The temperature for the tiger bush is in good agreement with the air temperature , 32.1 C, measured nearby (Monteny, 1997). The millet shows a little more spectral variation because of the possibility of some bare soil showing. Note, that even for a 600 m flight altitude the atmospheric correction was up to 2 K for the bare soil and about 0.5 K for the tiger bush. The same area was over flown on line 2 about 20 minutes earlier with similar results except that the temperatures were about 1 or 2 degrees cooler. This difference is somewhat greater than the air temperature difference between the two passes, i.e, about 0.5 C.

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The TES derived emissivities for these 3 sites are presented in Figure 2 for both the passes. The solid symbols are the results from line 2 and the open symbols with the dashed lines are for line 3. There is excellent agreement between the two lines. Especially for the bare soil case, where the emissivities for channels 1,2, and 3 are about 0.75 in both lines. There is a little more difference for the two vegetation targets especially for the millet field and for the shorter wavelength channels. Note that there are observation differences for the 2 lines; for line 2 the targets were in the northern half of the swath while for line 3 they were in the southern half of the swath and that at the 600 m altitude the scene is under scanned so that only about half of the area is actually seen. ~~So that~~ even if cover the same areas on both lines, slightly different pieces of the terrain may be seen. Thus for the millet field we may be responding to slightly different amounts of bare soil for the millet target on the two flight lines.

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When we compare the data for the same locations on the two days the agreement is less good as seen in Figure 3, but still not bad. Here the open symbols and dashed lines are for the results from September 2. Again the agreement for the vegetation targets at the longer wavelength channels (4 and 5) is quite good. The agreement is less good for channels 1 and 6 indicating that the atmospheric correction may not have been as good on 2 September. Also note that the derived temperatures were cooler on 2 September, about 2 C for the tiger bush and 7 C for the bare soil. Indeed the sky was cloudier on this day and the air temperature was about 2 degrees cooler on 2 September as reflected in the derived temperatures for the tiger bush.

## 3. DISCUSSION and CONCLUSIONS

A version of the TES algorithm was implemented and tested on several 1000-scan TIMS scenes for the East and West Central sites in the HAPEX Sahel experiment. The scenes were from 5 different flight lines on 2 and 4 September 1992 from an altitude of 600 m. There is excellent reproducibility when the same area is seen in different lines on the same day. However there are differences when the same area is seen on the two days especially for the low emissivity values. Some of these differences may be due to soil moisture differences which were observed on the two days (Chanzy et al, 1997). The resulting temperatures for the

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vegetated areas are in good agreement with the air temperature at the time of the flight. There was very little emissivity variation observed for TIMS channel 5 over the scenes and much of that is due to the noise in the MMD values. This limits the high values of emissivity obtained with the TES algorithm, e.g. over vegetation. Since channels 1 and 6 of TIMS were seen to have the largest noise, we implemented the TES algorithm using only center 4 channels of TIMS with some what better results. A more complete presentation of these results is available in the literature (Schmugge, et al., 1997). The further analysis of these data will involve the integration of the TIMS data with VNIR data from SPOT and the NS001 multispectral scanner.

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4. Acknowledgement

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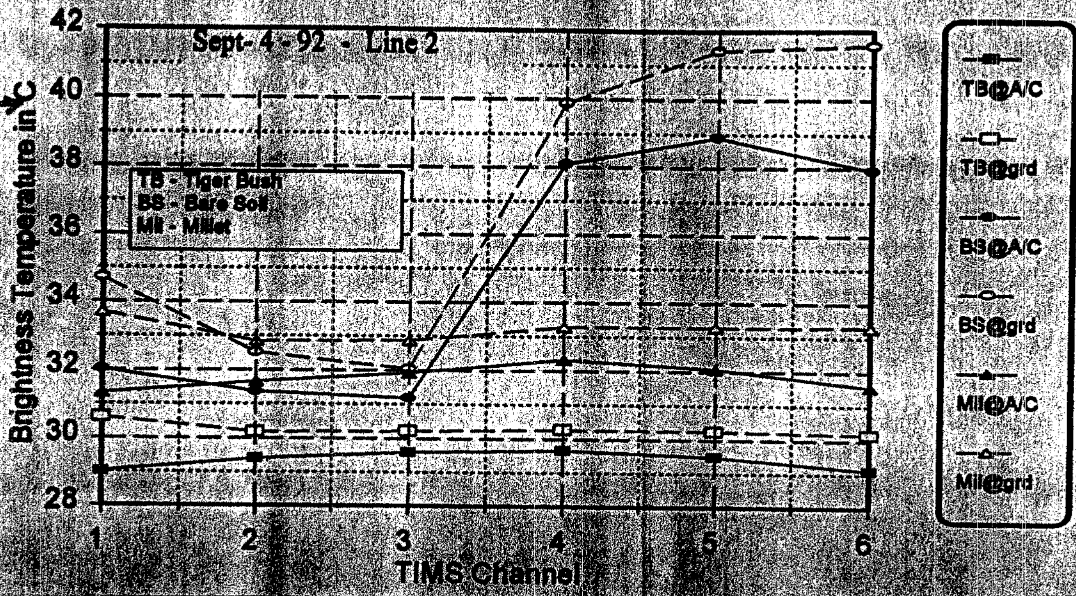


Figure 1. $T_B$ values for 3 targets at the East Central Site. The solid symbols are the values at the aircraft and the open symbols are the values at the ground.

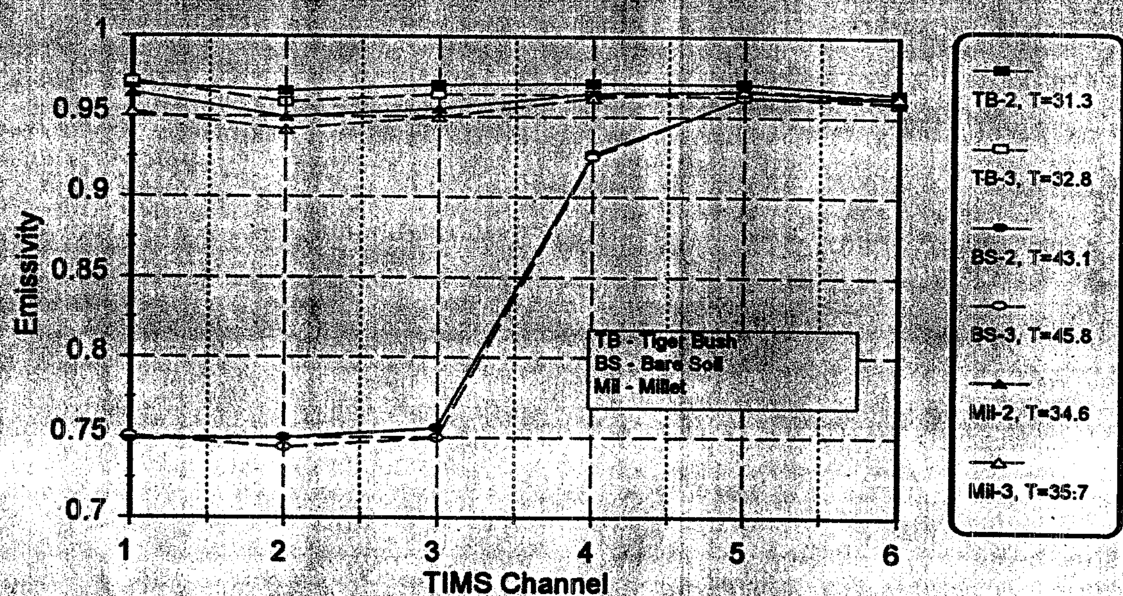


Figure 2. Comparison of derived emissivities for lines 2 and 3 on September 4. The values of the derived temperature are given in the legend. The solid symbols are for line 2 and the open are for line 3.

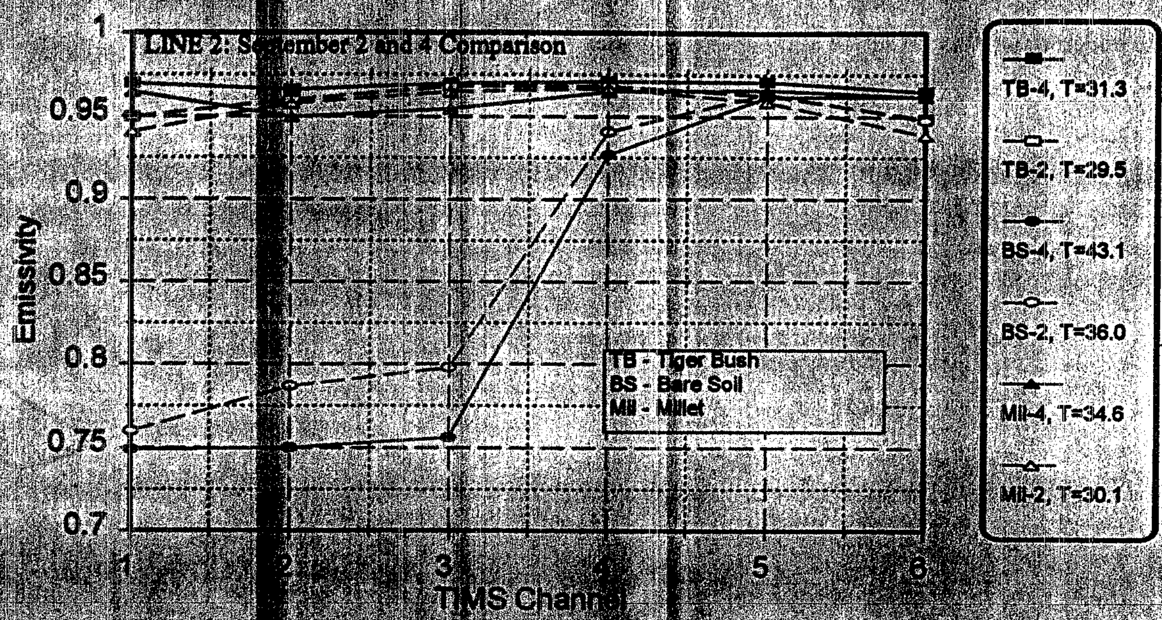


Figure 3 Comparison of derived emissivities for line 2 on September 2 and 4. Again the values of the derived temperature are given in the legend. The solid symbols are for September 4, the open for September 2.